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Establishing Feed Intake and Growth Curves for Individual Growing-Finishing Pig Units

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Introduction

In order to get a better understanding of levels of growing-finishing (G/F) pig performance, and to identify means to improve these, G/F pig performance should be closely monitored. The need for performance monitoring is illustrated by the large variation in performance levels and profitability between G/F pig units. In particular, for the development of farm specific feeding programs that involve phase and split-sex feeding, it is essential that estimates of feed intake and (lean) growth are obtained at the various stages of growth, i.e. that feed intake and growth curves are established. Furthermore, variation in performance should be considered, especially when determining the optimum use of space.

At the University of Guelph, a computerized performance monitoring system has been developed that can be used to establish unit specific feed intake and growth curves. The computer program, PorkMa$ter, can also be used to estimate profitability. The latter is expressed as gross margin per pig and gross margin per pig place per year. Additional information that is required to estimate profitability includes: initial and final body weight, weight range over which diets are fed, animal mortality, feed wastage, costs of feed and weaner pigs, variable costs per pig, fixed costs per pig place per year, variation in growth rate (open days per pig place per rotation), carcass dressing percentage, variation in shipping weights and carcass lean yields, the carcass grading and payment system.

In this paper, the application of PorkMa$ter is discussed and a specific example will be given on how the program can be used to assess the consequences of alternative shipping strategies. Even though reference will be made to one specific program (PorkMa$ter), the emphasis is on the principles of developing feed intake and growth curves. Alternative and similar programs are available or under development. These programs may be just as useful as PorkMa$ter in assisting pork producers to improve profits in G/F pig units.

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Establishing feed intake and growth curves

Even though average feed intake levels and growth rates differ between individual G/F pig units, feed intake and growth curves generally follow a predictable pattern. This implies that mathematical equations can be used to represent the general shape of feed intake and growth curves. The parameters included in these mathematical equations will differ between individuals of G/F pig Units

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(Schinckel and de Lange, 1996). For example, a mathematical equation that represents a typical signoidal growth curve, the Gompertz function, is given in equation 1. By changing the two parameters in this equation, the body weight at maturity (A) and the rate constant (b, a value that determines how quickly mature body weight is reached), a whole range of different growth curves can be fitted. Unfortunately, this Gompertz function is not always sufficiently flexible. More complex mathematical equations are sometimes required to fit growth curves for individual G/F pig units. The type of mathematical equation will determine how many observations are needed to fit these curves for individual G/F pig units (Schinckel and de Lange, 1996).

Equation 1. $\text{Body weight (kg)} = A * e^{\text{Ln}(1.5/A)*e^{-b*\text{time}}}$

Where:
A = body weight at maturity
b = rate constant
body weight at time 0 is assumed to 1.5 kg

In PorkMa$ter, two different mathematical equations are included to fit the growth curve (body weight vs. time); the Gompertz function and a more complex generalized non-linear function (Equation 2: Schinckel and de Lange, 1996). A minimum of five data points are required for curve fitting. Each data point should represent one group - usually one pen - of pigs. For each data point, the average body weight and the number of days since a common initial body weight (average weight of pigs entering the G/F unit) should be determined. In a "continuous flow" operation, these growth curves can be developed very quickly as data points can be obtained simultaneously from different pens in the unit.

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Equation 2.

$$\text{Body weight (kg)} = \left[\frac{1.5}{1-e^{-a}}\right] * \left[1-e^{-a-b*\text{time}-c*\text{time}*\text{time}}\right]$$

Where:
a, b, c are parameters
body weight at time 0 is assumed to be 1.5 kg

For fitting feed intake curves (feed intake vs. body weight), two equations are included in PorkMa$ter as well - an exponential function (Equation 3) and a generalized asymptotic function (Equation 4) (de Lange et al., 1993). In addition, some mathematical functions are included to reflect a (rapid) change in feed intake level when diets are changed. This applies when a high, energy-dense grower diet is changed to a finisher diet with a lower energy density. Again, a minimum of five data points are required for curve fitting. It is suggested that at least two observations are made per diet. Each data point should represent the feed usage of one group of pigs (one pen or one feeder) determined over at least a two week period. In addition, the average body weight of these groups of pigs over these periods should be determined. If feed intakes are established over periods that are shorter than two weeks, feed intakes will appear highly variable and the fitted intake curve will not be very reliable (de Lange et al., 1993). In a "continuous flow" operation, these feed intake curves can be developed from observations obtained over a two week period as data points can be obtained

simultaneously from different pens in the unit. Relatively simple and inexpensive devices are now available to weigh the amount of feed placed into feeders.

Equation 3. Feed intake (kg/d) = $a*BW^b$

Where:
BW = body weight (kg)
a and b are parameters

Equation 4. Feed intake (kg/d) = $a*(1-e^{BW*b})$

Where:
BW = body weight (kg)
a and b are parameters

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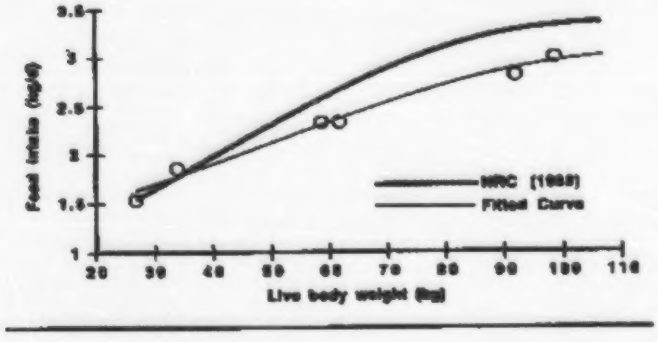
When observation on body weight vs. time and feed usage vs. body weight are used to fit the growth and feed intake curves, it is important to assess the accuracy and/or reliability of the fitted curves. This can be done visually, using graphs (Figure 1) and statistically. The variability of data points and accuracy of fitted curves will vary considerably between different G/F pig units. A high variability of observations within units and a poorly fitted curve are often a reflection of sub-optimal management.

Figure 1



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For this reason, the process of developing feed intake and growth curves in itself can already be a useful exercise. Because of differences in variability between units, it is not possible to provide some "rules of thumb" on how many observations are required to develop reliable feed intake and growth curves. It is our experience that on well managed farms, six data points that are spread out over the entire body weight range should result in reliable growth and feed intake curves. As the overall performance calculations are sensitive to feed intake and

growth rates in pigs just prior to market weight, it is important that observations are made in pigs that are close to market weight.

It is suggested that feed intake and growth curves be established routinely and at least twice per year. This is to reflect (seasonal) changes in performance within G/F pig units.

PorkMa$ter does not generate lean growth curves. In the program, only the average lean growth rate over the entire G/F phase is calculated. It is calculated from the determined average lean content in the carcass (an input into the program), an assumed average lean content in the pig's body at the initial body weight (35% of initial body weight) and the estimated average number of days to grow from initial to final body weight. It can be argued that for the development of multiple phase feeding programs, the actual lean growth curve needs to be estimated. However, for the development of lean growth curves, the lean content in the pig's body at various body weights needs to be estimated. This requires that serial body measurements be taken (using real time ultrasound or equivalent technologies), and that relationships between these measurements and the actual lean content at the various body weights have been established for that particular type of pig (Schinckel and de Lange, 1996). In most situations, more basic information is thus required before reliable lean growth curves can be established. For the development of two or three phase feeding programs, an estimate of average lean growth rate over the entire G/F phase is probably sufficient for most pig types. Moreover, if multiple phase feeding programs are developed, the use of dynamic pig growth models is recommended (de Lange and Schreurs, 1995). These models can be used to re-predict lean growth curves from the observed growth and feed intake curve provided that assumptions are made about maintenance energy requirements (de Lange and Schreurs, 1995; Schinckel and de Lange, 1996). These models can also be used to identify what determines lean growth at the various body weight ranges. For example, energy intake may determine lean growth at lower body weights, daily amino acid intake at intermediate body weights and the pigs' performance potential as pigs approach market weight. This information is useful when identifying means to improve and/or manipulate the observed average lean growth rate.

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Determining the optimum shipping weight: A case study

The optimum shipping weight is determined by two main factors: 1) the marginal costs of producing the last kg of body weight and; 2) the change in carcass value at increasing body weight. The first is largely determined by feed costs (feed efficiency around market weight and price of the finisher feed). The second is largely determined by changes in carcass weight and carcass lean yield as body weights increase. The information can be obtained from feed intake and growth curves and the settlements that producers receive from the packing plants or marketing boards. The latter should allow producers to relate lean yield to hot carcass weight (or to body weight at shipping if assumptions are made about the carcass dressing percentage; hot carcass weight will generally be between 78 and 80% of body weight at shipping).

As there are considerable differences between G/F pig units in (lean) growth and feed efficiency around market weight, it is important that these changes in feed efficiency and carcass lean yield with increasing body weight can be determined for individual units.

An important part to consider, at least in Canada, is variation in carcass weights. This variation determines the distribution of pig carcasses over the various weight classes. In the Canadian carcass grading and price settlement system, the carcass index (a relative value per kg carcass assigned to each individual carcass) is determined by the estimated lean content in the carcass and the

weight of the carcass. In other words, average lean yield and average weight in a group of pigs may be close to the optimum; but if carcass weights are too variable, a substantial proportion of pig carcasses may be outside the optimum weight range and hence would receive a low carcass index. In PorkMa$ter, this variation is mathematically expressed as the standard deviation (SD). This value should be determined from at least 100 individual carcass weights. If pigs are shipped weekly and the body weights of pigs that are shipped are closely monitored, the SD on carcass weight will likely be around 4 kg. This means that 66% of the carcass weights will be between the mean minus 4 kg and the mean plus 4 kg, i.e. within a window of 8 kg. If pig body weights at shipment are not closely monitored, or when pigs are shipped every two weeks on the SD on carcass weight can easily approach 6 kg.

In Tables 1 and 2, the estimated effects of shipping weight and variation in shipping weight on gross margin per pig and gross margin per pig place per year are presented, respectively. These values are related to Ontario conditions in the spring of 1997 and relate to pigs with a slightly better than average lean growth potential, that maintain this lean growth rate up to high body weights, and that consume "average" levels of feed. In these analyses, the effect of removing pigs from pens on performance of pigs remaining in the pens is ignored. When producers are interested in profit per pig (i.e. pig space is not a concern), the optimum average shipping weight is likely to be around 110 to 113 kg body weight. Outside of this range, losses will quickly exceed $2 per pig. When producers are interested in profit per pig place per year (i.e. trough-put; pig space is a concern) the optimum average shipping weight is likely to be around 108 to 110 kg body weight. The data in Table 2 illustrates that increasing the SD in shipping weight by only 2 kg, i.e. from 4 to 6 kg, will reduce the average profit per pig by more than $3.50 per pig!! These values are unlikely to change very much due to (slight) changes in average growth rates due to removal of pigs from pens and increased handling of pigs.

The results presented in Tables 1 and 2 clearly illustrate the benefits of monitoring and manipulating average AND variation in shipping and carcass weights. Once feed intake and growth curves are established and settlements from packing plants or marketing boards have been interpreted, these analyses can be conducted for any pork production unit and for any carcass grading grid when using PorkMa$ter or similar programs.

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Table 1. Estimated effect of optimum shipping weight on gross margin per pig and gross margin per pig place per year.*

Final Weight, kg	**105.8**	**107.6**	**110.3**	**113.0**	**115.6**
Avg. carcass weight, kg	84.6	86.9	88.7	91.2	93.6
Avg. carcass index	108.6	108.8	108.1	105.8	101.5
Feed cost; $/pig	49.58	50.86	52.80	54.75	56.72
Gross margin; $/pig*	29.56	31.95	33.88	33.06	28.39
Gross margin; $/place/year**	95.50	101.40	104.81	99.72	83.57

*costs and prices: grower diet $235.1/tonne; finisher diet $221.6/tonne; weaner pig price $80/pig; variable cost $15/pig; carcass bid price $1.90/kg; 5% mortality; 14 open days per rotation. **gross margin per pig: carcass value-weaner pig price-feed cost-variable costs per pig; gross margin per pig place per year: gross margin per year *365/(days to market + open days per rotation). Calculated using PorkMa$ter 1997.

Table 2. Estimated effect of variation in shipping weight on gross margin per pig and gross margin per pig place per year at each of two final weights.*

Final Weight, kg	107.6	107.6	110.3	110.3
Standard dev., kg	4	6	4	6
Avg. carcass index	108.8	106.5	108.1	105.5
Gross margin, $/pig	31.95	28.25	33.88	29.52
Gross margin; $/place/yr	101.40	89.67	104.81	91.32

* as in Table 1.

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Conclusion

For various reasons, it is important to establish feed intake and growth curves for individual growing-finishing pig units. As the pattern of feed intake and growth is predictable, some generalized mathematical equations can be used to develop feed intake and growth curves on individual units based on detailed observations on representative sub-samples of pigs. It is suggested that at least five data points are used to establish feed intake and growth curves. An example was provided to illustrate the use of feed intake and growth curves for evaluation alternative shipping strategies.

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